Towards an Empirical model of the Solar Wind Charge Exchange

Eugenio Ursino, Wenhao Liu, Massimiliano Galeazzi, Kip D. Kuntz, Dimitra Koutroumpa, Steve Snowden

Towards an Empirical model of the Solar Wind Charge Exchange

Eugenio Ursino, Wenhao Liu, Massimiliano Galeazzi, Kip Kuntz, Dimitra Koutroumpa, and Steve Snowden
University of Miami, Johns Hopkins University, Universite Versailles St-Quentin (France), NASA/GSFC

Abstract

We present the preliminary results of the study of Solar Wind Charge eXchange (SWCX) based on a Suzaku Key Project and archival data. With a three-year monitoring campaign of four nearby (~100 pc) high column density clouds that absorb almost all the background photons, the key project is focused on measuring the temporal evolution of the local soft X-ray emission and characterization of SWCX emission. Comparing the X-ray emission with the product of the ACE and WIND satellites, we are developing a model of the SWCX X-ray contribution as a function of line of sight, position of the Earth and Sun, and the flux of neutrals in the solar wind.

Solar Wind Charge eXchange

The Solar Wind Charge eXchange (SWCX) is due to the interaction of the solar wind with neutrals and it includes two components: geocoronal and heliospheric. Spatial and temporal variations depend on the relative positioning between the observer, the Sun, and the line of sight, and on the solar activity.

- Geocoronal SWCX has a very short time scale (hours to days) and possibly very strong emission bursts, due to the interaction of solar wind with neutrals in our atmosphere.
- Heliospheric SWCX has smooth variations and a time scale (days to months), due to the diffusion time of the wind through the solar system. It also has an annual modulation due to distributions of interstellar neutrals (H and He) passing through the solar system. Heliospheric is on average the dominant component.

SWCX Intensity:

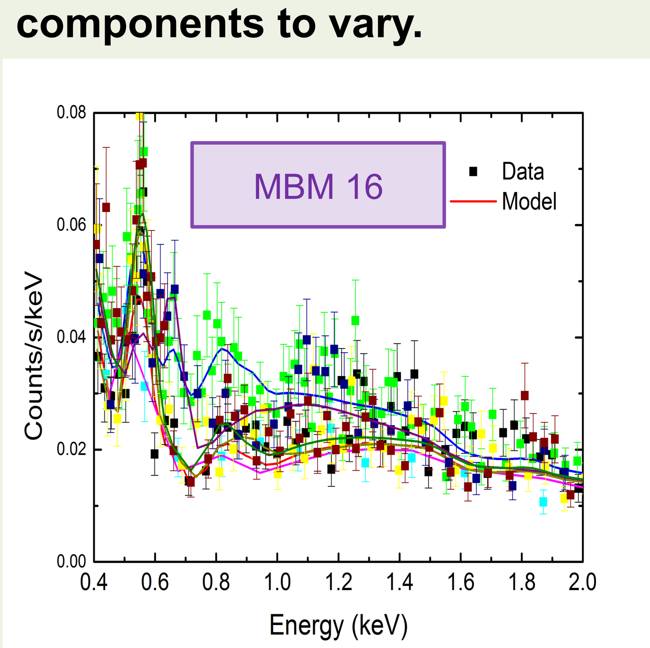
$$I_{OVII} = \int \alpha_{O7+}\, n_{7+}\, (n_H + n_{He}) < g > ds,$$

$$I_{OVIII} = \int \alpha_{O8+}\, n_{O8+}\, (n_H + n_{He}) < g > ds,$$

- $<g>$ is average total solar wind speed (bulk and thermal). α is the abundance-weighted sum of the cross-sections.
- **ACE and WIND monitor solar wind activity and provide solar wind parameters and energetic particle intensities ($<g>$, n_{O7+}, and, n_{O8+}).**
- **The objective of the Key project is to measure and characterize heliospheric components: the distribution of neutrals n_H and n_{He} in the solar system, the cross sections α, and investigate the fast solar wind at high ecliptic latitude.**

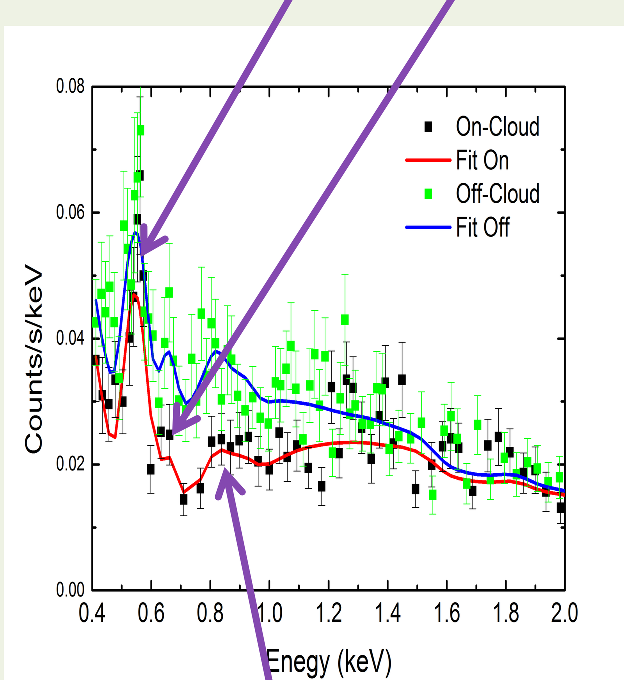
Spectral Analysis

We did a global fitting for all datasets target by target, only allow SWCX (OVII and OVIII) components to vary.



The LHB temperature and density are constrained to the results from the ROSAT and DXL surveys (see 200.05 by W.L.).

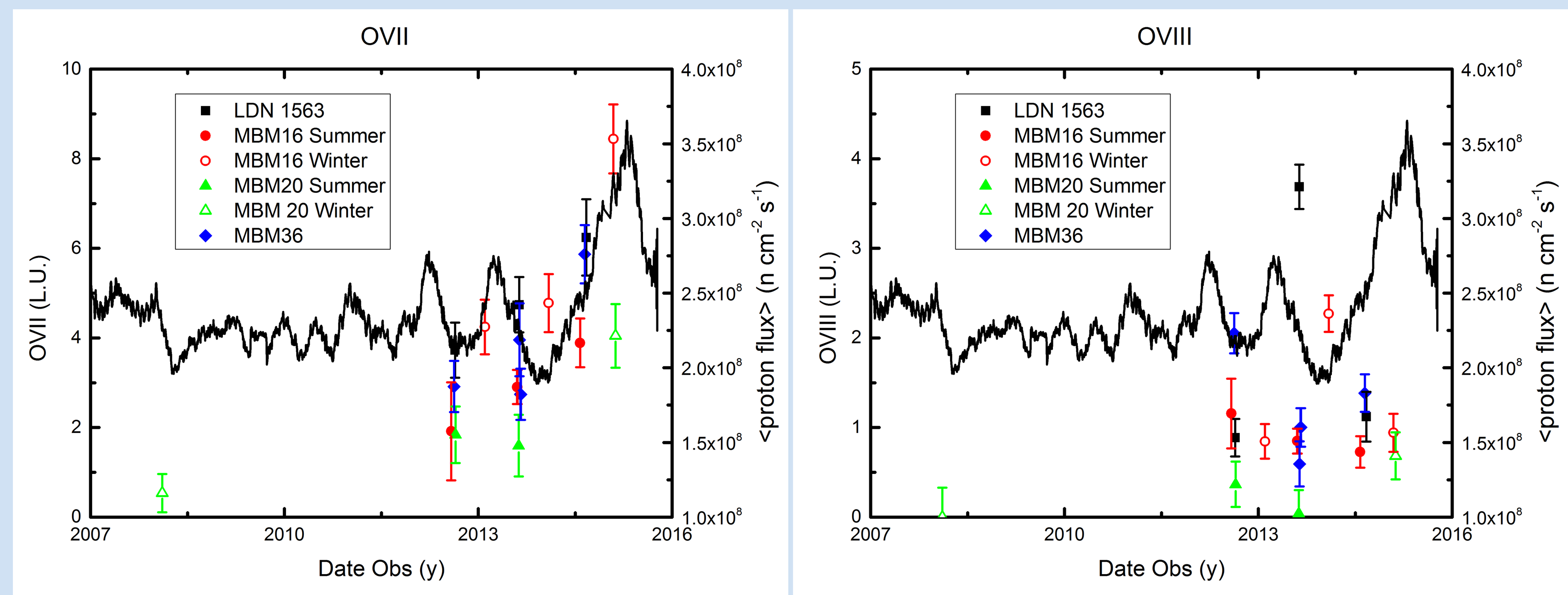
Highlights of OVII and OVIII lines in sample dataset and fit model for MBM16.



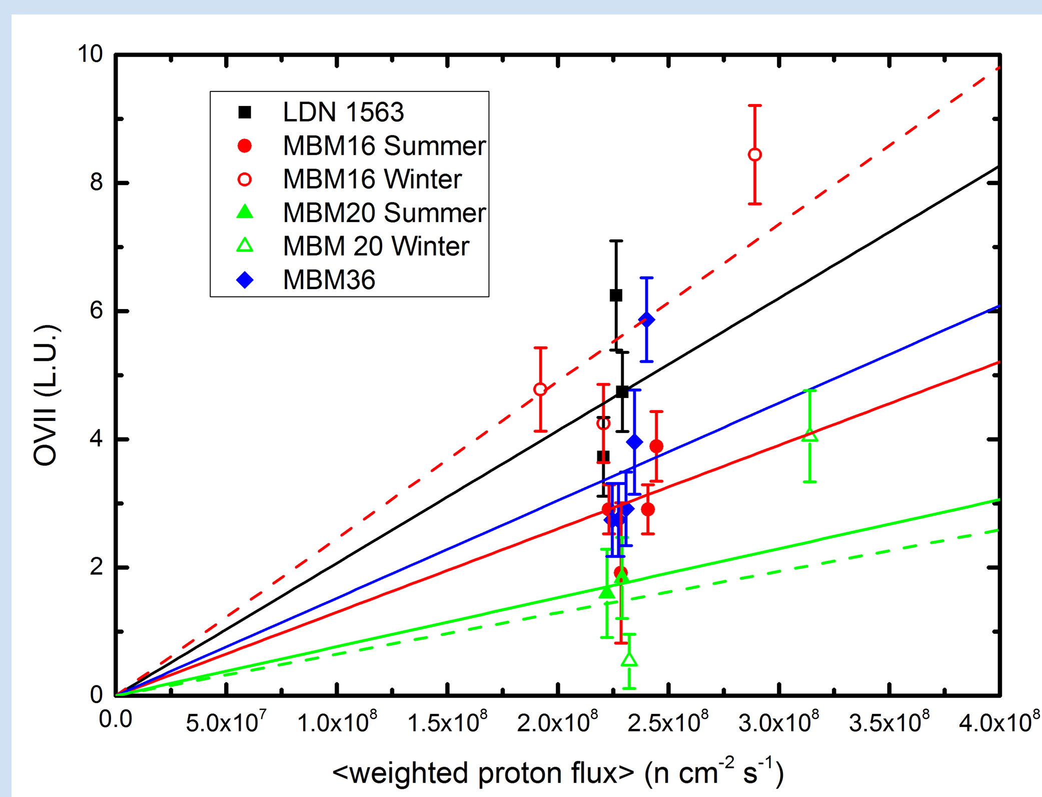
There is a bump at ~0.8 keV showing on both on-cloud (high NH) and off-cloud (low NH). Is it a possible SWCX line or due to thermal emission besides LHB?

Results (part I)

The temporal evolution of the O VII emission and of proton flux show remarkably similar trends.



The average proton flux as an indicator of the O VII emission.



- **MBM 16 shows significant variations between the summer and winter observations as a result of intersecting the He focusing cone. The winter observations show a larger ratio between OVII and proton flux.**
- **LDN 1563 has the largest ratio of all summer observations. In summer its line of sight is the closest to the focusing cone.**
- **MBM 36 looks upstream toward the H Maximum Emission Region. The density integrals in the lines of sight is almost the same as MBM 16 (summer) and the two targets have a very similar ratio.**
- **MBM 20 has the largest ecliptic latitude and the smallest ratio.**
- **The first and last observations of MBM 20 have been performed in winter.**

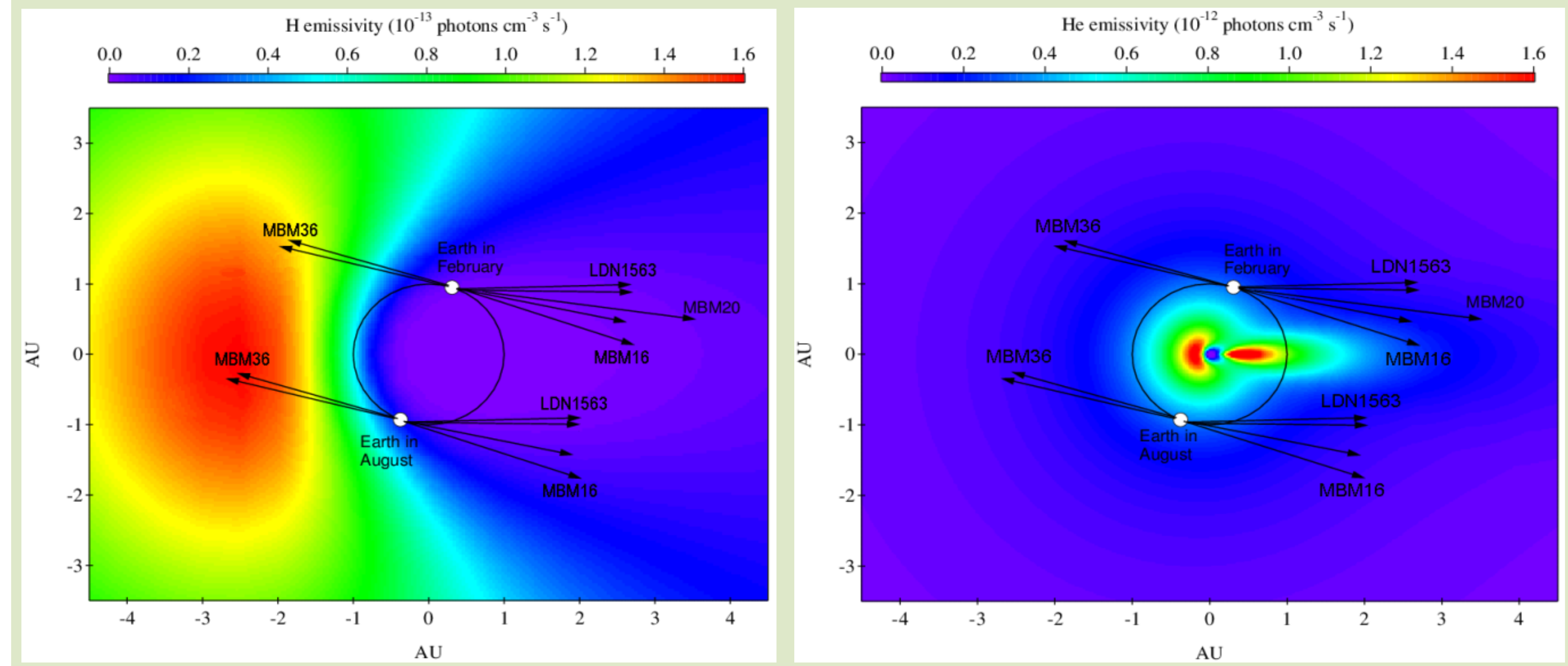
Future Work

We are developing a semi-empirical model using our Suzaku pointings, to estimate the SWCX and remove its effect from any past, present, and future X-ray observations of diffuse objects, which will be web portal accessible to the community. We'll include additional targets that have been repeatedly observed with Suzaku and XMM.

Target Selection and Strategy

The selection criteria is to cover the largest range of solar wind conditions and neutral distributions with the least number of targets.

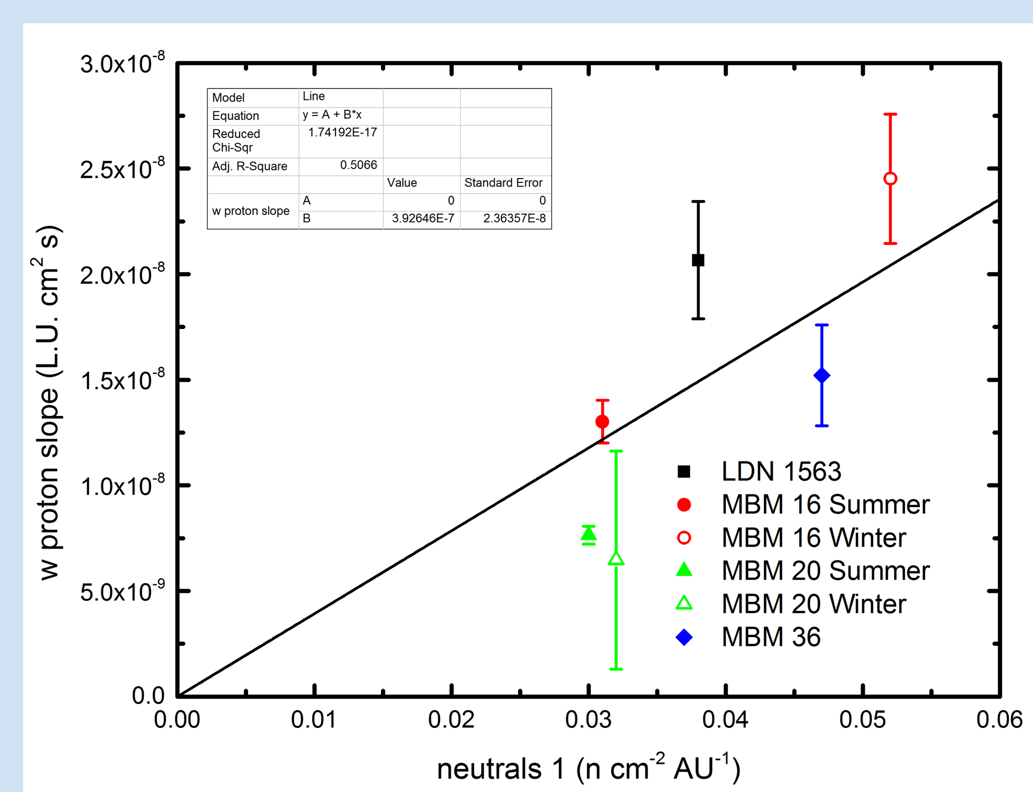
Target	RA	DEC	NH	Ecliptic longitude	Ecliptic latitude
LDN1563	05 02 06.00	13 52 00.0	4.12E21	76	-9
MBM16	03 19 04.10	11 34 52.0	3.32E21	50	-7
MBM20	04 35 45.60	-14 37 38.0	1.59E21	64	-36
MBM36	15 53 26.50	-04 47 07.0	3.76E21	237	15



- **Three targets (MBM 20, MBM 36, LDN 1563) were monitored once a year; One target (MBM 16) was monitored twice a year to study variations in February when the pointing is partially through the He focusing cone;**
- **One target (MBM 36) looks upstream to the H and He flow into the solar system, the other three look downstream and give us the largest range of ecliptic latitude and longitude;**
- **MBM 20 is the target with the largest ecliptic latitude to investigate the neutral distribution outside the ecliptic plane.**

Results (part II)

We can simplify the problem by measuring only the proton flux (WIND, ACE) and the density of neutrals along a line of sight.



A simplified equation for the SWCX emission:

$$I_{OVII} = \beta\,(n_H + n_{He})\, f_p$$

- **From Part I we have $\beta\,(n_H+n_{He})$ for each target.**
- **We can compute n_H and n_{He} for each target.**
- **We obtain a proportionality constant.**